

**IN THE UNITED STATES  
PATENT AND TRADEMARK OFFICE**

**TITLE:**

**MOTION SICKNESS/VERTIGO PREVENTION DEVICE AND METHOD**

**INVENTOR:**

**HANAN BUTNARU**

442033000000

**BACKGROUND OF THE INVENTION**

This application claims the benefit of U.S. Provisional Application Nos. 60/011,895, filed on February 15, 1996, and 60/017,753, filed on May 15, 1996.

**1. Field of the Invention**

The present invention relates generally to a device for the relief of nausea, disorientation, and other disabling symptoms resulting from sensory mismatch and, more particularly, to an artificial labyrinth which provides the user an alternate means of determining his actual, physical orientation with respect to the surrounding environment.

**2. Background of the Invention**

Motion sickness does not discriminate. It can attack anyone, at any time. It is always disabling, to a greater or lesser degree, depending on the person. It is known from research that certain types of sensory mismatch are the leading cause of motion sickness. This mismatch occurs when the brain perceives that the body is in motion (through signals originating in the labyrinth and transmitted to the brain by the vestibular nerve system), but the motion sensed does not match what the eye can see and verify. The reverse is also true (i.e. sensory mismatch may also occur when the eye perceives motion, but the labyrinth does not provide confirming signals to the brain). There are many causes of this mismatch, including: time delay between the arrival of labyrinth motion signals and visual confirmation signals within the brain, or conflict between these signals when they do manage to arrive at the same time. In addition, the labyrinth's signals may be corrupted by various physical defects, conflict with each other within the labyrinth, or be missing entirely, as is the case when a person has the vestibular system disconnected (via operation, accident, or birth defect). All causes of this type of sensory mismatch are not precisely known, but it is well-established that such conditions can drastically affect an individual's quality of life and performance of everyday tasks.

One example of sensory mismatch is vertigo, which is the sensation the brain encounters when it perceives that the body is in motion (when in fact there is no motion), and it attempts to correct bodily

1 posture to counteract the perceived physical sensation. Another example of sensory mismatch occurs when  
2 the eye perceives motion, but no motion actually occurs. This can be described as a type of "virtual reality"  
3 sickness, which is normally experienced users of video games or flight simulators. The reverse situation,  
4 when the body feels motion but there are no visual cues, is a much more common occurrence. Examples  
5 include: passengers in an airplane with no access to a window, sailors in a submarine, and ship passengers  
6 that cannot see the horizon. Such persons sense actual changes in body position, but have nothing in the  
7 environment which allows their eye to confirm the motion they perceive.

8 It is not clear why some persons can tolerate sensory mismatch better than others. However, at  
9 some point, almost everyone is affected when the mismatch is severe. This is especially true for those who,  
10 through accident or genetic deficiency, suffer from vestibular system dysfunction. That is, even though the  
11 person is sitting or standing in a stationary fashion, they have the constant feeling of motion and, as a result,  
12 sickness. Simply bending over or slight movement of any kind may result in total disability in these cases.  
13 In the United States alone, over 30,000 vestibular section operations occur each year to help those suffering  
14 from Meniere's disease (i.e. vertigo induced by a distended labyrinth) get some relief, which drugs alone  
15 can't provide. However, rehabilitation after such an operation may require months of therapy.

16 Several attempts have been made to alleviate the symptoms of motion sickness (e.g., drugs which  
17 numb the nervous system and give some relief from nausea), but no successful product exists to eliminate  
18 the cause of motion sickness. Even if the resulting nausea is somewhat lessened, the sensory mismatch still  
19 exists, and may cause the affected person to make improper or dangerous decisions when accomplishing  
20 everyday tasks, such as driving an automobile.

21 Thus, there exists a long-felt and widespread need to provide alternative environmental orientation  
22 information (i.e. "visual cues") which can be used by the brain to replace erroneous or missing sensation  
23 signals normally provided by the natural labyrinth, and which can be readily confirmed by the natural vision  
24 system. The method and apparatus of the present invention, discussed in greater detail below, clearly  
25 satisfies this need.  
26

1 SUMMARY OF THE INVENTION

2 The present invention provides an artificial labyrinth which augments or replaces the natural  
3 labyrinth. It functions by sending visual cue orientation information directly to the eye for transmission to  
4 the brain. After some training by the user, the brain will learn to compare the artificial labyrinth orientation  
5 cue information with the visual perception of the user, and to disregard misleading natural labyrinth signals.  
6

7 The artificial labyrinth can exist in the form of a wearable accessory usable by any number of  
8 people; it can be integrated into glasses already worn for vision correction, or can be used with an  
9 independently wearable frame or other apparatus which enables a portable system to be devised. It is  
10 specifically designed to take advantage of miniature gyroscope, accelerometer, magnetostrictive sensor, or  
11 other attitudinal sensing technology to produce a device and method which give the user constant visual cues  
12 as to his orientation with respect to the surrounding environment. Such cues, when substituted by the brain  
13 for erroneous signals sent by a dysfunctional labyrinth or vestibular system, serve to eliminate sensory  
14 mismatch and the resulting sensations of nausea or vertigo.

15 Visual cues can be supplied in a number of ways, including: a series of lines projected into the  
16 space in front of the user by way of a display or projection mechanism such as the commercially-available  
17 "Private-Eye™"; direct projection of visual cues onto the retina; laser holography; or some type of averaged  
18 video display which records the image in front of the user, and re-displays a series of averaged video frames  
19 to the user's eye in order to give the appearance of a stable platform -- much like the technology some  
20 commercial movie cameras use to stabilize an image while the camera is being moved during operation.

21 In the presently preferred embodiment, by way of example and not necessarily by way of  
22 limitation, the artificial labyrinth makes use of a triaxial accelerometer to produce visual cues indicating the  
23 user's actual pitch and roll motion. The accelerometer is mounted on the user's head and the resulting  
24 electrical output from each axis (which reflects movement) is sampled every 10 msec. After 12 sample  
25 cycles occur (120 msec), the accelerometer signal data is averaged for each axis, compared with the user's  
26 baseline position (i.e. at rest), and translated into visual cues for display. The visual display is updated

1 several times a second (at least every 150 msec) so that reference orientation cues are timely delivered to  
2 the eye for transmission to the brain. It has been determined through experimentation that such feedback  
3 eliminates sensory mismatch between the labyrinth/vestibular system and the visual system, so as to give  
4 relief to many who suffer from vertigo or motion sickness.

5 The basic system can also be enhanced by the inclusion of magnetic sensors, which allow the  
6 addition of visual cues to indicate the yaw of the user. Thus, users can receive visual verification of  
7 rotational changes which occur to the left or right about a vertical axis which extends from the head to the  
8 toes. Elevational changes can likewise be communicated to the user by way of visual cues, as well as other  
9 useful, but non-orientation related (e.g. mapping or message) information.

10 The artificial labyrinth satisfies a long existing need for a system capable of quickly, accurately,  
11 and inexpensively eliminating the sensory mismatch which is induced by environmental conditions or  
12 labyrinth/vestibular system disfunction. The above and other advantages of this invention will become  
13 apparent from the following more detailed description, in conjunction with the accompanying drawings and  
14 illustrative embodiments.

#### 15 **BRIEF DESCRIPTION OF THE DRAWINGS**

16 Fig. 1 is a perspective view of the present invention as worn by a user.

17 Fig. 2 is a stylized example of a visual cue display.

18 Figs. 3(a)-(d) are various representations of the visual cue display as it reflects the true position  
19 of the user with respect to his environment.

20 Figs. 4(a)-(h) are alternative representations of the visual cue display as it reflects the true position  
21 of the user with respect to his environment.

22 Fig. 5 is a simplified block diagram of an alternative embodiment of the invention.

23 Fig. 6 is a simplified block diagram of an alternative embodiment of the present invention.

24 Fig. 7 is a block diagram of an alternative embodiment of the present invention, realized as an  
25 operational system.  
26

1 Fig. 8 is a summary flow chart illustration of the processing steps for implementing the method  
2 of the present invention.

3 Fig. 9 is a block diagram of an alternative embodiment of the present invention.

4 Fig. 10 is a stylized representation of the visual cue display with user messaging capability.

5 Fig. 11 is a simplified block diagram of an alternative embodiment of the present invention.

6 Fig. 12 is a perspective view of an alternative embodiment of the present invention indicating a  
7 user's perception of a projected visual cue image.

8 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

9 Fig. 1 illustrates a perspective view of one embodiment of the present invention, as it may be worn  
10 by a user. Glasses frames (40) encompass lenses (90), which provide a display to the user having fixed  
11 orientation marks (200) and movable visual cue orientation marks (100).

12 Turning now to Fig. 2, orientation markings (100 and 200) are shown as a stylized representation  
13 of one possible display perceived by the user of the instant invention. Moveable visual cue marks (100)  
14 are displayed in relation to a field of fixed orientation marks (200). Moveable visual cue marks (100) will  
15 change their position with respect to fixed orientation marks (200) whenever the position of frame (45)  
16 changes with respect to the true horizon. If orientation sensors (10) are mounted to a frame (45), which  
17 is in turn affixed to the user's head, the display presented to the user will correspond roughly to that shown  
18 in Fig. 2 when the user's head is positioned so as to be straight and level,

19 Turning now to Fig. 3, it can be seen how the position of moveable visual cue marks (100) will  
20 change with respect to fixed orientation marks (200) as the user's head position changes. Figs. 3(a)-(d)  
21 show how the display changes when the user's head moves up, down, left, and right, respectively. Such  
22 changes assume that all orientation sensors are affixed to the user's head (e.g., by using glasses frame (40)).

23 The changing orientation display gives the user visual cues as to the difference between his head  
24 position and that of his environment. Thus, users experiencing nausea and/or vertigo because they lack  
25 knowledge as to their physical position within the environment now have access to a simple means of  
26 determining their true relative orientation.

Fig. 4 illustrates several additional examples of visual cues which can occur in the present invention. It should be noted that such visual cues are by no means limited to those shown in the accompanying figures. That is, instead of various combinations of dashed or dotted lines, and the geometric shapes shown, other forms of visual cuing are contemplated. For example, the intensity or color of the display can be varied over its entire surface, or in specified areas, to indicate various conditions of orientation. Colors may be bright or muted, intensities may also be brightened or dimmed, and geometric figures or indicators can change shape, color, or intensity to indicate various orientations to a specific user. In addition, display visual cues can be tailored to each individual user, so that the user need only adapt to those visual cues he needs to properly navigate in his own environment and avoid the disabling affects of vertigo and motion sickness.

Fig. 4(a) represents a display providing two additional elements contemplated by the present invention. Vertical yaw bars (500) are used to indicate rotational position changes about an axis which extends from the head to the toes of the user. Elevational bubble (510) is used to indicate changes in altitude of the user's body from an initial baseline position. As can be seen in Fig. 4(b), the user has rotated toward his left about the central axis of his body. In Fig. 4(c), the user has rotated toward his right. In Fig. 4(d), the user has been elevated to some distance above an initial baseline rest position, and in Fig. 4(e), the user has been moved to a lower elevation than he initially encountered at the baseline rest position.

The present invention also anticipates a combination of visual cues from any number of orientation sensors, all operating at the same time. That is, a particular user may require roll (rotational movement about an axis which extends from the front to the back of the user), pitch (rotation about an axis which extends from the left to the right of the user), yaw (rotational movement which occurs about an axis which extends from the head to the toes of the user), and elevation (change in altitude above or below a baseline rest position) change information simultaneously. Fig. 4(f) illustrates such a combination of visual cues. In this case, the user has pitched backward and rolled to the left. Altitude and yaw remain unchanged. Note that elevation bubble (510) is now located at the side of the display. The present invention contemplates location of various visual cues at any place on the display which is convenient to the user, and

1 most effective at transmission of orientation information to the brain for processing. Fig. 4(g) indicates that  
2 the user has pitched forward and rolled to the right. Elevation and yaw remain unchanged. Finally, Fig.  
3 4(h) indicates that the user has rolled to the right, yawed to the right, and been elevated upwardly. Pitch  
4 has not changed. All orientation marks in Fig. 4(h) (both moving and stationary) have been relegated to  
5 the periphery (75) of the display (50). This allows use of the display for unobstructed views of objects in  
6 front of the user, while still providing needed visual orientation cues.

7 Turning now to Fig. 5, a simplified block diagram of the preferred embodiment of the present  
8 invention can be seen. Frame (45) may consist of glasses frame (40), as shown in Fig. 1, or any other  
9 convenient means to mount the required components of the present invention, so as to make them easily  
10 transportable by the user. Orientation sensors (10) are preferably mounted to frame (45). Orientation  
11 sensors (10) can be any type among several commonly available, including gyroscopic, accelerometer, or  
12 magnetostrictive. Orientation sensors (10) are energized by power source (30), which can be batteries or  
13 some other portable mechanism (e.g., solar). Power source (30) also supplies power to microprocessor (20)  
14 and other elements, such as a display (50) or projector (60), which are also preferably mounted to frame  
15 (45). The output of orientation sensors (10) is sent to microprocessor (20) and translated by means of a  
16 program into display commands for display (50) or projector (60) mounted on frame (45). If display (50)  
17 is used, it must be transparent so as to interpose only the orientation markings (100 and 200) as shown on  
18 lenses (90) in Fig. 1 between the eyes of the user and his environment. The display (50) mechanism can  
19 be affixed to corrective lenses or incorporated into clear glass or other transparent material for use with  
20 frame (45).

21 An alternative means of presenting orientation markings (100 and 200) for perception by the user  
22 is to make use of a projector (60) to replace the function of display (50). Projector (60) is preferably  
23 mounted onto frame (45) in such a way as to project out into space in front of the user, by laser beam  
24 holographic means or other means, a display similar to that shown in Fig. 1, to include orientation markings  
25 (100 and 200). Commands to projector (60) are derived from signals produced by microprocessor (20) in



1 response to input provided by orientation sensors (10). The projected display should preferably appear to  
2 be located several feet in front of the user.

3 An alternative embodiment of the invention is shown in Fig. 6. In this case, no visual cue marks  
4 are displayed. The means to give the user visual clues as to orientation is now effected by producing an  
5 averaged semi-real-time display of what normally would be viewed through the lenses (90) of glasses frame  
6 (40) (of Fig. 1). In this case, a microprocessor (20) is powered by power source (30) which also provides  
7 power to a camera (70) (or series of cameras) and a projector (60). Camera (70) and projector (60) are  
8 preferably both mounted on glasses frame (40). In this embodiment of the instant invention, camera (70)  
9 can be used to produce a recorded image of the scene in front of the user. The recorded image is sent to  
10 microprocessor (20) and averaged with other images produced by camera (70) so as to produce what is  
11 perceived by the user to be a slowly changing display of the visual environment. This changing display is  
12 projected onto lenses (90) for actual perception by the user via projector (60). Thus, the user does not  
13 perceive the actual scene as recorded by camera (70), but only the averaged image as displayed by projector  
14 (60) on the inner surface of lenses (90).

15 Turning now to Fig. 7, an operational realization of the preferred embodiment using conventional  
16 components can be seen. Power source (30) is used to supply microprocessor (20) and, indirectly, display  
17 (50) and orientation sensors (10). Microprocessor (20) is composed of a personal computer central  
18 processor unit (300) or equivalent, connected to conventional random access memory (310), and non-volatile  
19 memory (320).

20 Projection display (390) is directly connected to display controller (380), which in turn is interfaced  
21 to a serial port on the central processor (300). A program is resident in the non-volatile memory (320), and  
22 used to direct the display controller (380), so as to project a series of visual cues onto projection display  
23 (390). Random access memory (310) is used as a scratchpad memory to store sensor input information and  
24 make calculations to update the visual cues sent to projection display (390) via display controller (380).  
25 The combination of analog-to-digital converter (330), analog multiplexer (340), and sample-and-hold (350)  
26 are integrated into a single circuit card made by Crossbow (Part No. CXLDK RS232, digital interface card),

1 or equivalent. Orientation sensors (10) may take the form of a triaxial accelerometer (360), also made by  
2 Crossbow (Part No. CXL04M3) and three magnetostrictive sensors (Honeywell Part No. HMC1001).

3 Turning now to Fig. 8, a summary flow chart sequence of events necessary to effect the method  
4 of the present invention, given the specific implementation as shown in Fig. 7, can be seen. In step (400),  
5 the system is powered-up and microprocessor (300) is used to initialize display control (380) and scratch  
6 pad random access memory (310). In addition, the data acquisition sub-system consisting of analog-to-digital  
7 converter (330), analog multiplexer (340), and the sample-and-hold (350) are reset and prepared to accept  
8 data from accelerometer sensors (360) and magnetic sensors (370) in step (420).

9 Accelerometer sensors (360) are responsive to the Earth's gravitational field, which is relatively  
10 constant in magnitude and direction. The amount of angular tilt or acceleration experienced by each of  
11 accelerometer sensors (360) is passed on to sample-and-hold (350) in the form of a voltage, which is  
12 proportional to the change between the baseline (i.e. rest) position, and any newly measured position.  
13 Likewise, magnetic sensors (370) are responsive to changes in the Earth's magnetic field. Given a constant  
14 current input, the resistance of magnetic sensors (370) will change in proportion to changes in magnetic field  
15 strength. Thus, magnetic sensors (370) also provide a voltage indicative of positional change (from a  
16 baseline) to sample-and-hold (350).

17 To obtain a baseline (resting or initial reference) position measurement, accelerometer sensors (360)  
18 and magnetic sensors (370) are placed on a stable, non-moving surface, and the data acquisition sub-system  
19 consisting of analog-to-digital convertor (330), analog multiplexer (340), and the sample-and-hold (350) are  
20 calibrated by subjecting the system to test voltage inputs over a specific range (e.g. 0.0 to 5.0 volts), and  
21 obtaining a range of expected conversion values (i.e. conversion slope) in step (430). In step (440), the  
22 system is programmed to take about 100 samples from each sensor. These samples are averaged for each  
23 sensor, and recorded as the initial baseline (i.e. "at rest") position in step (450).

24 Now the microprocessor (300) enters a program loop which begins at step (460) and requires taking  
25 orientation sensors (10) data every 10 msec to produce a data set consisting of 12 samples of each sensor  
26 (e.g., 4 sensors X 12 samples = 48 samples in the set, if orientation sensors (10) consist of a triaxial

1 accelerometer and a single magnetostrictive sensor), every 120 msec. In step (470), microprocessor (300)  
2 calculates the average position derived from the sample data for each sensor.

3 Finally, in step (480), the average measured position for each sensor is compared to the baseline  
4 position and the new, updated position sensed by the orientation sensors (10) is presented to the user via  
5 projection display (390) after the appropriate commands have been sent to display controller (380).

6 In this particular implementation of the preferred embodiment, the microprocessor (300) will look  
7 to see if any key on the computer keyboard (not shown) has been pressed in step (490). If it has, then the  
8 microprocessor (300) will exit from the data acquisition and positional update loop if the key pressed was  
9 an "ESCAPE" in step (500). If the key pressed was not an "ESCAPE", then microprocessor (300) will loop  
10 to step (460) and begin to acquire a new multi-sample data set based on any changes in orientation as sensed  
11 by accelerometer sensors (360) and magnetostrictive sensors (370).

12 If the microprocessor (300) has sensed an "ESCAPE" key input in step (500), then projection  
13 display (390) is cleared of all visual cues and the system is prevented from acquiring any more position-  
14 dependent data or displaying changes in that data in step (520), and the program is halted.

15 The spirit of the present invention anticipates the partition of the data acquisition, data processing,  
16 and visual cue display functions of the system into separate units, or combined into a single monolithic unit.  
17 Implementation as separate units can be seen in Fig. 7, although other methods of partition are possible.  
18 For example, the data acquisition and display functions can be combined into a single head-mounted unit,  
19 and the data processing system can be remotely located to reduce weight and/or power requirements. In  
20 Fig. 9, the data acquisition function of the present invention is implemented by using a power source (30)  
21 to supply the data acquisition sub-system (consisting of analog-to-digital convertor (330), analog multiplexer  
22 (340), and the sample-and-hold (350)), data transmitter (600), and various orientation sensors (10),  
23 consisting of accelerometer sensors (360) and magnetostrictive sensors (370). In this system, positional  
24 input data is provided by the orientation sensors (10), acquired by the data acquisition sub-system, and  
25 provided to the data transmitter (600) for transmission to the data processing sub-system.

1 The data processing sub-system consists of a data transceiver (620) which sends the acquired data  
2 from orientation sensors (10) to a finite state machine (630) for processing. A power source (30) is also  
3 required at this juncture to energize data transceiver (620) and finite state machine (630). After processing  
4 of the positional sample data is completed, finite state machine (630) sends the resulting display controller  
5 information, along with any other data which may be desired (e.g., GPS, altitude, etc.), to the data  
6 transceiver (620). At this point, all data is received by data receiver (610) and passed on to display  
7 controller (380) for presentation to the user at projection display (390). Again, a power source (30) is used  
8 to supply the requirements of the data receiver (610), display controller (380), and projection display (390).  
9 It should be noted that all data communications which occur between data transmitter (600), data receiver  
10 (610), and data transceiver (620) can be effected by either radio frequency means, infrared means, or other  
11 wireless methods of communication.

12 Many other possible implementations will suggest themselves to those skilled in the art. For  
13 example, this invention may be used in either civilian or military applications. Referring now to Figures  
14 10, 11, and 12, an enhanced version of the invention can be seen. In this case, orientation information is  
15 projected out into space, several feet in front of the wearer, and provided at the periphery of the wearer's  
16 vision area (75). A miniaturized radio data receiver (e.g., cellular phone with modem, or similar device)  
17 (190) can be added to the basic system shown in Figure 2, so that microprocessor (20) may also receive data  
18 which is unrelated to the user's position within his environment (See Fig. 10). Circuitry similar to that used  
19 in modern cordless or cellular phones, or digital messaging pagers, can also be used to directly interface  
20 with the microprocessor for wireless data transfer (20). In a military application, such information as target  
21 speed (80) and altitude (90) can be displayed at the top of the wearer's vision area display, and real-time  
22 messages which give an indication to the wearer of target proximity could be displayed in a "movie  
23 marquee" fashion at the bottom of the display (100). The center of the display (110) can be left open, as  
24 shown in Figure 10, for display of any type of information which can be received over the radio/data link.  
25 The use of such display messaging in the military version of this invention obviates the need for verbal  
26 communications in many circumstances. This can be a real advantage in the battlefield or other situations

1 where verbal or sonic communication is undesirable. The visual cue orientation display may also be  
2 superimposed onto a virtual reality display field (e.g. video games, flight simulators, etc.) or presented in  
3 conjunction with night-vision display applications. In naval or marine applications, the entire system worn  
4 by the user may have to be constructed in a water resistant or waterproof fashion. In this case, the central  
5 display area (110) might be used to display fleet position information (mapping) to the wearer.

6 It is not necessary in all circumstances to provide visual cue information to each eye of the wearer.  
7 In low cost civilian applications, for example, only a single display element may be required. See Fig. 12.  
8 Various methods of mounting the display are possible. For example, a band (120) can be used to mount  
9 the unit on the head of the wearer with a simple extendable arm (130) to place the display (50) in front of  
10 the wearer's eye (e.g., similar to the inspection mirror worn by doctors, or some jeweler's loupes).  
11 Physically, display (50) is preferably about one square inch in size. However, the user will actually perceive  
12 a display image (140) which is much larger, and projected out into the space in front of him. The invention  
13 for civilian use should be very light weight, inexpensive and rugged. If a radio data receiver is used with  
14 the visual cue display, such information as news, weather updates, or other information of interest can be  
15 displayed in an updated fashion on the peripheral edges of the display.

16 Turning now to Figures 11 and 12, it can be seen that other embodiments of the invention may  
17 include a three-axis accelerometer (150) in place of the orientation sensors (10) shown in Figure 2. Of  
18 course, three separate single-axis accelerometers can also be used to replace orientation sensors (10). The  
19 use of accelerometers in place of a gyroscope will allow cost savings in some instances, and increase the  
20 ruggedness of the device.

21 In more sophisticated versions of this device, the display can be adjusted by the wearer to  
22 compensate for vision deficiency (i.e., diopter adjustment, similar to that used in binoculars) so that the  
23 projected information display appears to be in perfect focus at a distance from the user. This adjustment  
24 can be programmed into the microprocessor (20) by sensing a user-controlled input (160), or mechanically  
25 adjusted by moving the display (50) closer to or farther away from the user's eye.

1 Display (50) can be manufactured so that it is capable of displaying different elements in color.  
2 This will allow the wearer to immediately differentiate background information from priority or emergency  
3 information (e.g., emergency information can be displayed in red, while all other information is displayed  
4 in black and/or yellow). Display (50) can also be manufactured with a filter component to protect the eye  
5 of the wearer from damage by intense sources of electromagnetic energy. This may include simple  
6 polarizing filters or some type of material whose optical transmission properties can be adjusted to protect  
7 the eyesight of the wearer, depending on the optical sensing properties of the display material, or of an  
8 additional electromagnetic sensor (170) connected to microprocessor (20). Finally, retinal scanning, such  
9 as that described in "A Retinal Display for Virtual Environment Applications" (Proceedings of Society for  
10 Information display, 1993 International Symposium, Digest of Technical Papers, Vol. XXIV, pg. 827) or  
11 holographic projection, can be used to present appropriate visual cues to the user, with additional  
12 communications or message data if desired. Such technology would obviate the need for fixed display  
13 means for providing visual cues to the user.

14 An alternative embodiment of the present invention may also include GPS (global positioning  
15 satellite) information processing capability. That is, messaging display (50) can present location information  
16 to the user, or a map display which is automatically updated as the user moves along terrain. GPS  
17 information processing capability is also useful to underwater divers. In this case, the diver's underwater  
18 position updates could be displayed in real-time as GPS receiver (180) obtains locational updates from  
19 satellites overhead and ports the resulting data to microprocessor (20).

20 In order for the implementation of the present invention to be effective, it is important that the  
21 visual cue display information be processed and analyzed in a timely manner. This means that the display  
22 update for orientation visual cues (i.e. "physical sensation" information) should not lead or lag visual  
23 verification by a time period of greater than 150 msec, which means that orientation sensors (10) must  
24 normally be mounted on the head of the user. Head mounting of orientation sensors (10) will speed up the  
25 acquisition of any movement sensation resulting from changes in user physical position. If the orientation  
26 sensors (10) are mounted at some other location, it may be more convenient for the user, but may not be

a 1 as effective at elimination of sensory mismatch as would direct mounting to the user's head. However,  
2 there may be instances in which the user desires to monitor the motion of an object <sup>moving with his</sup> ~~other than his~~ own  
3 body, in which case the orientation sensors (10) must be mounted directly to that object, such as a car or  
4 airplane in which the user travels. In the described implementation of the embodiment depicted by Fig. 7,  
5 it was determined that a sensor sampling period of 120 msec, coupled with calculation of position change  
6 and display update commands of less than 30 msec, was sufficient to eliminate sensory mismatch (i.e. the  
7 display was continuously updated with new positional change information every 150 msec, or less). By  
8 supplying the user's brain with true conditions of motion within the required time period, sensory mismatch  
9 is eliminated and the user is relieved of vertigo and/or nausea that may result. This invention is also useful  
10 to those who have undergone the procedure of vestibular nerve section. Usually it takes months of  
11 rehabilitation to overcome the effects of such a procedure, but with the use of the present invention it is  
12 believed that rehabilitation can occur much more rapidly and successfully. Use of the artificial labyrinth  
13 will also lead to reductions in rehabilitation cost, since patients can get back to work more quickly, and  
14 <sup>used to relieve</sup> ~~to~~ the symptoms of sensory mismatch are avoided.

15 Although the invention has been described with reference to a specific embodiment, this description  
16 is not meant to be construed in a limiting sense. On the contrary, even though only specific devices have  
17 been shown to be mounted to the glasses frames, all elements of the instant invention can be mounted on  
18 these frames, given sufficient miniaturization. Also, various alternative stylized displays can be used, other  
19 than that shown in Fig. 3. As long as the user is given visual orientation cues which reflect motion such  
20 as pitch, roll, yaw, or elevation of his body with respect to the environment, the spirit of this invention is  
21 effected. This includes the use of mechanical orientation sensing devices placed within the user's normal  
22 viewing field to give appropriate visual cues. Other various modifications of the enclosed embodiments will  
23 become apparent to those skilled in the art upon reference to the description of the invention. It is,  
24 therefore, contemplated that the following claims will cover such modifications, alternatives, and equivalents  
25 that fall within the true spirit of the scope of the invention.